PRELIMINARY NOTES ON SOME IGNEOUS ROCKS OF JAPAN. III[1]

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III. ALKALI-FELDSPAR-BEARING BASALTIC ROCK (FUKAE-GAN) AND ALKALI-FELDSPAR-BEARING BASALT

Localities.—Alkali-feldspar-bearing basaltic rocks were collected from Fukae-shima in the Gotō Islands; alkali-feldspar-bearing basalts from Madara-shima, an islet northwest of the Yobuko port, prov. Hizen; from Ō-shima, near the Island of Iki; from Uramino-taki, near Omura city, prov. Hizen. These localities are in the northern part of Kyûshû or its outlying islands.

Occurrence.—The rock type, associated with olivine-basalt on the one hand and with soda-trachyte[2] on the other, appears to have an extended distribution over the northern part of Kyûshû. At Fukae-shima, this rock group forms the plateau and some striking dome-shaped hills standing on it, as seen in the photographs (Figs. 1 and 2). There are well preserved or strongly breached craters in the summit of each dome. The hills, in great part, consist of ashes, lapilli, and slaggy lava, in which finely shaped bombs may be found abundantly. The plateau is of hard lava.

Age.—Near the close of Tertiary to Diluvium.

The specimens for the following descriptions were collected by the writer from Fukae-shima; by Y. Ōtsuki from Madara-shima and Ō-shima; and by D. Satô from Uramino-taki. They may be classified in two groups by the mineralogical and chemical characters.

I. *Alkali-feldspar-bearing basaltic rock (Fukae-gan in Japanese).*—The rocks of this group collected from Fukae-shima are transi-

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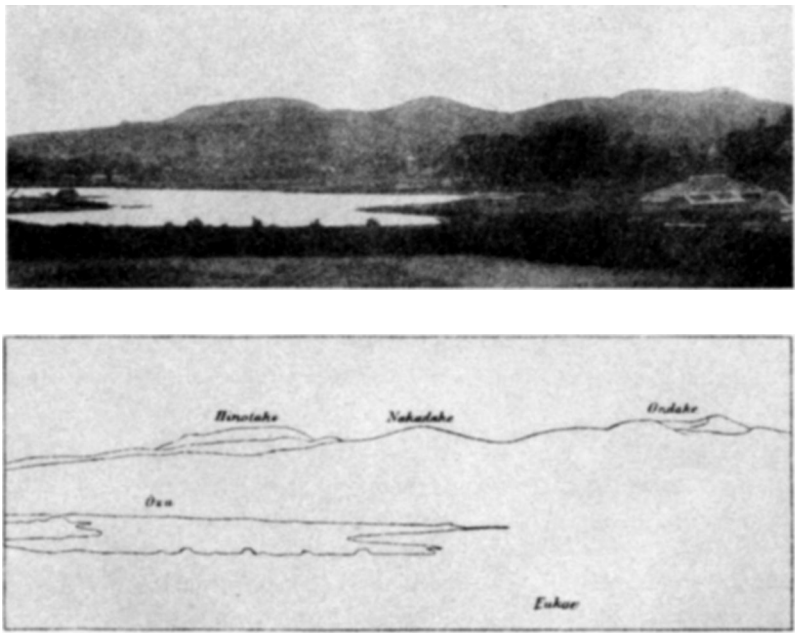
[2] *Jour. Geol.*, XIX (1911).

tional forms in both texture and mineralogical characters, owing to their crystallinity, but are closely alike in chemical properties. They are represented by three types as described below.

As the first type, a bomb ejected from the volcano Ondake was selected for the following description and chemical analysis:



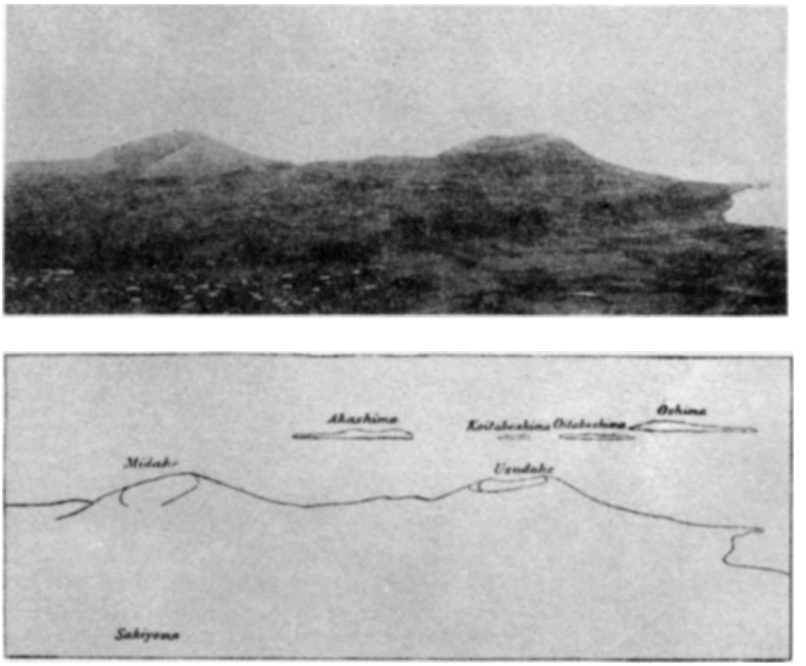
View from the northwest

FIG. 1

Megascopic characters.—This rock type is aphanitic and black in color. Scattered magnophyric feldspars are the only constituents visible to the naked eye. The groundmass is vesicular, and the vesicles are small and round. The phenocrysts are of fresh aspect and show rather euhedral forms, short prismatic or tabular, and in some instances are of considerable size, reaching 20 mm. in length (Fig. 3). Olivine, which is present as abundant microscopical phenocrysts, is scarcely recognizable even by the aid of a lens.

Microscopical characters.—The microscopic phenocrysts in this type of rock are of olivine in great part, with subordinate andesine. The groundmass is hypocrystalline and is filled with small and round vesicles (Fig. 4), looking like the outline of leucite.

Feldspar.—This mineral shows distinctly two different habits. The phenocrysts are stout prismoid, sometimes tabular, and some-



View from the north west

FIG. 2

what rounded. They are andesine (Ab_3An_2), with a mean index of refraction slightly higher than $n_y = 1.554$. They contain abundant small particles forming an outer zone, and round it usually, thin and clean layers with different composition, but the difference between each layer is not pronounced. Twinning is scarce, and in rare instances undulatory extinction can be observed. Feldspars forming the groundmass are slightly more sodic than the phenocrysts, and occur in elongated or rather slender shapes. They are

marked by irregular cracks, filled with isotropic, low refractive, and colorless, substance. Twinning according to the albite law is common.

Olivine occurs in two-sized crystals. The larger ones are abundant and play an important rôle as microscopic phenocrysts. Their shapes are equant or prismoid. In many instances, the outlines of crystals are irregular by invasion of groundmass, sometimes

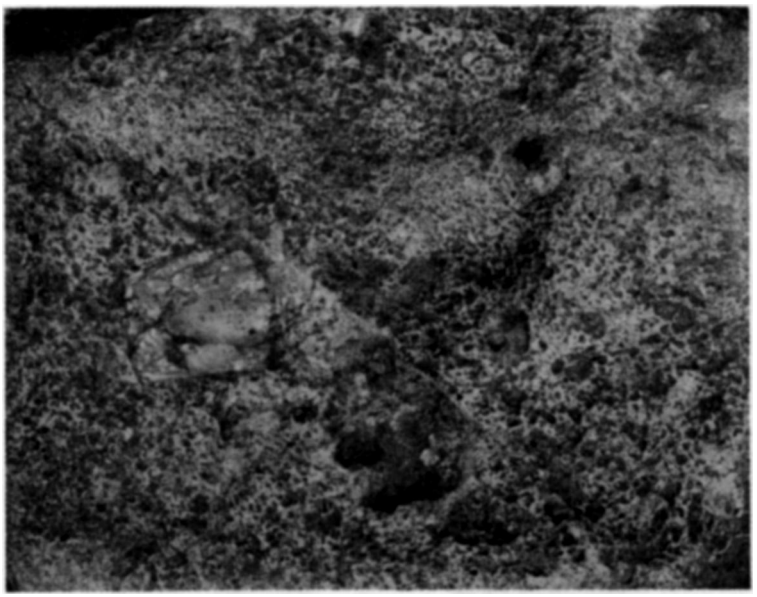


FIG. 3.—Andesine phenocryst, natural size

extremely narrow and deep, parallel to crystallographic faces, showing the successive growth of the mineral, but the general outlines are referable to crystal forms (Figs. 5 and 6). Though distinctly cracked they are entirely fresh and inclose clouded glass, but are free from other inclusions.

Augite forms magnophyric crystals which are very rarely seen in hand specimens. The minute grains in the base, showing high refraction, appear to be augite.

Magnetite clouds the base as minute grains or dusty particles, and their abundant presence affects the color of the rock. *Apatite* appears mostly as inclusions in feldspar.

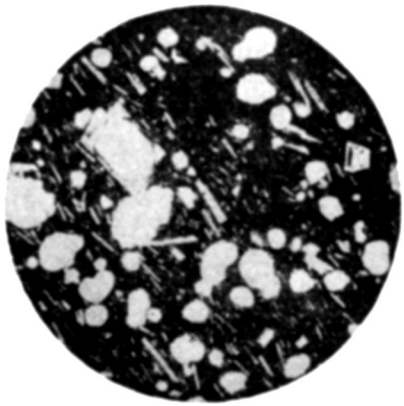


FIG. 4.—Microphotograph of the first type of the first group, magnified 30 times. The minerals seen in the figure are olivine microphenocrysts and andesine prisms.

The second type collected from Ohama in Fukae-shima is more crystalline. Alkali-feldspar appears locally in the crystalline part as the border of the plagioclase of the groundmass. The augite crystals are comparatively few and occur in small anhedral forms. The magnetite crystals are more numerous in this type of rock than in the first one, are somewhat larger, but are also anhedral in shape (Fig. 7).

The third type collected from Masuda in Fukae-shima is holocrystalline, and in some parts has typical ophitic texture. The

FIG. 5

FIG. 6

FIGS. 5 AND 6.—Showing irregularly outlined olivines. ×55

mineral components are andesine, alkali-feldspar, augite, olivine, magnetite, and apatite. The andesine is distinctly cracked, with

invasion of colorless, low refractive and isotropic substance as in the above types. The alkali-feldspar occurs as the border of almost all crystals of andesine in the groundmass. The augite is light purple in color, and is xenomorphic toward plagioclase. The magnetite frequently occurs in crystal form.

II. *Alkali-feldspar-bearing basalt.*—

This group differs from the above in the presence of labradorite in the place of andesine, as the essential component.

The specimen from Madara-shima is dark reddish gray in color with semiwaxy luster. It is holocrystalline, fine granular, and

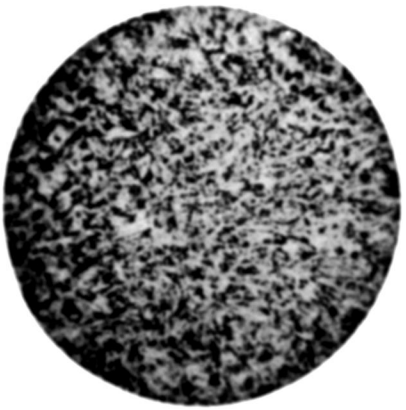


FIG. 7.—Microphotograph of the second type of the first group. ×30.

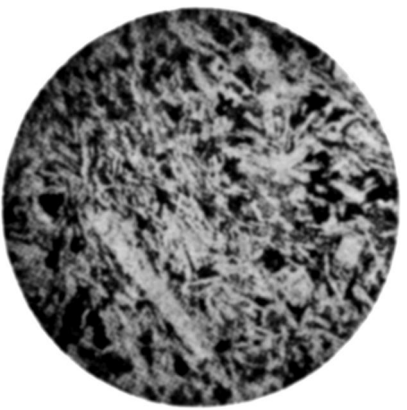


FIG. 8.—Microphotograph of the third type of the first group. ×30.

inconspicuously porphyritic, with not abundant magniphyric feldspar and less pyroxene.

Under the microscope the rock consists of labradorite, alkali-feldspar, augite, olivine, titaniferous iron ores, and apatite. The labradorite is subhedral to euhedral, twinned according to the Carlsbad and albite laws, and commonly prismatic in shape. Zonal structure is rarely seen. Each of the feldspar crystals composing the groundmass is enveloped by a shell of alkali-feldspar. The augite is light greenish yellow with purple tinge, and is subhedral to anhedral, stout prismatic to equant. The larger ones are indistinct phenocrysts; the minute grains are interstitially distributed in the groundmass with magnetite crystals. The olivine

as microscopic phenocrysts is subhedral to anhedral, and alteration into iddingsite is commonly visible along cracks and in marginal portions. The texture of the groundmass is somewhat intersertal, and is characterized by divergent arrangement of prisms of plagioclase enveloped by alkali-feldspar, with interstitial granules of augite, olivine, and magnetite (Fig. 9).

A more distinctly crystalline and coarser type is a specimen from Ō-shima, an islet, near the Island of Iki.

Megascopically the rock, more or less decomposed, is evidently holocrystalline, but the individual crystals are scarcely recognizable, though the diverse arrangement of prismoid feldspars, 1.5 to 2 mm. long, is well marked in the hand specimen. The color is light gray, on account of the abundant feldspars, and is dotted by dull reddish brown spots produced by decomposition of the olivine. Rare, inconspicuous phenocrysts are tabular, white feldspar; irregularly shaped black augite; and equant, dark reddish olivine. All of them are less than 3 mm. in diameter.

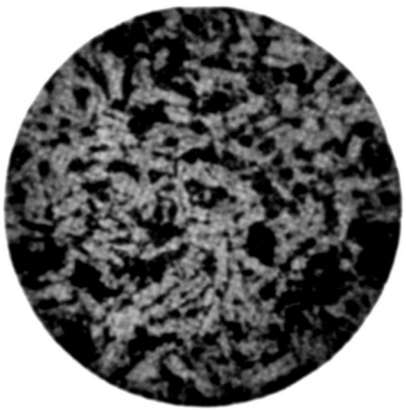


FIG. 9.—Micropnotograph of the alkali-feldspar-bearing basalt from Madara-shima. ×30.

Under the microscope (Fig. 10), the texture is transitional from doleritic to intersertal, as the augite is xenomorphic toward feldspar in one case and automorphic in the other. The mineralogical constituents are as before, but the presence of broad bands of alkali-feldspar enveloping labradorite is especially noticeable (Fig. 11). In some crystals, the alkali-feldspar has more than three times the volume of the labradorite, that is, 0.75 mm. in length and 0.09 mm. in width (Fig. 11). In general, the labradorite is in extremely elongated prisms, twinned according to the Carlsbad and albite laws. The augite is anhedral to subhedral, prismatic to equant. In color it is light purple. The magnetite frequently occurs in

anhedrons 0.35 mm. in diameter. The apatite is noticeable in elongated prisms.

The most finely grained variety is from Uramino-taki. It is light gray, compact with a few vesicles, and nonporphyritic, sometimes with nodular olivine. There are groups of scaly, blackish brown mica in the vesicles.

Under the microscope it is almost holocrystalline and granular. The mineralogical components are the same as in the previous variety, with a small quantity of biotite, which usually occurs in cavities. The biotite is reddish brown and strongly pleochroic. Its apparent optical angle ($2E$) varies between $37.5°$ and $29.5°$.

FIG. 10

FIG. 11

Chemical characters.—Of the first group of rocks a complete analysis was made of the first type (Bomb) and two partial analyses of the second (B) and third (C) types, by K. Yokoyama. Of the rocks of the second group a complete analysis of a specimen (D) collected from Marada-shima was made by T. Ōno.

The three analyses A, B, and C of the first group show a close relationship in chemical characters, notwithstanding they have different mineralogical components due to their crystallinity. Foreign rocks that have a close resemblance in chemical characters with the rocks of this group are olivine basalt (E) and orthoclase-bearing doleritic basalt (F) of New South Wales, described by

G. W. Card. For the sake of comparison, these analyses are given in the following table with those of the rocks under consideration.

	A	B	C	D	E	F	G
SiO_2	48.33	49.15	48.70	52.19	48.98	53.21	49.24
Al_2O_3	16.29	....	....	19.74	16.88	17.84	15.84
Fe_2O_3	3.24	....	....	4.72	3.30	3.80	6.09
FeO	8.73	....	....	6.28	7.29	5.22	7.18
MgO	5.70	....	....	2.24	5.27	2.96	3.02
CaO	8.50	....	....	6.99	8.86	6.48	5.26
Na_2O	3.59	3.64	3.35	3.48	3.39	3.36	5.21
K_2O	1.49	1.61	1.42	2.04	2.11	3.03	2.10
H_2O+	0.82	....	....	1.25	0.52	0.65	1.08
H_2O-					1.78	1.27	1.61
CO_2	n.d.	....	....	n.d.	0.06	0.02	n.d.
TiO_2	2.40	....	....	n.d.	1.28	1.01	1.84
P_2O_5	0.79	....	....	n.d.	0.30	0.44	1.47
SO_3	n.d.	....	....	n.d.	none	0.09	n.d.
Cl	n.d.	....	....	n.d.	0.02	0.11	n.d.
MnO	0.11	....	....	n.d.	0.31	0.32	0.29
etc.	....	....	....	0.06	0.06	....	0.21
Total	99.99	....	....	99.99	100.41	99.88	100.46
Sp.G.	2.562	....	....	....	2.869	2.768	2.79

A. Bomb ejected from the volcano Ondake, Fukae, the Gotō Islands, Analyst, K. Yokoyama.

B. Lava erupted from the volcano Ondake, Ōhama, Fukae, the Gotō Islands, Analyst, K. Yokoyama.

C. Lava erupted from the volcano Ondake, Masuda, Fukae, the Gotō Islands, Analyst, K. Yokoyama.

D. Lava, Madara-shima, prov. Hizen, Analyst, T. Ōno.

E. Olivine-basalt, one and a half miles north of St. George's head, N.S.W.

F. Orthoclase-bearing doleritic basalt, south side of Croobyar Creek, N.S.W.

G. Mugearite, Druim na Criche, 5 miles S.S.W. of Portree, Skye.

The norms calculated from these analyses are as follows:

	A	D	E	F	G
Quartz	....	3.2	....	4.9	....
Orthoclase	8.9	11.7	12.2	17.8	12.2
Albite	30.4	29.3	28.8	26.7	44.0
Anorthite	23.9	32.3	24.7	24.5	13.6
Sodium chloride	....	....	....	0.4	....
Diopside	11.0	2.1	14.6	3.9	3.4
Hypersthene	2.7	12.2	....	10.8	1.1
Olivine	11.5	....	9.7	....	7.6
Magnetite	4.6	6.7	4.9	5.6	8.8
Ilmenite	4.6	....	2.4	2.0	3.5
Apatite	1.9	....	0.7	1.3	3.1
	99.5	97.5	98.0	97.9	97.3

Ratios calculated from the norms are as follows:

	A	D	E	F	G
$\frac{Sal}{Fem}$	1.74	3.64	2.03	3.16	2.51
$\frac{Q+L}{F}$	....	0.04	....	0.009	....
$\frac{K_2O'+Na_2O'}{CaO'}$	0.86	0.66	0.87	0.99	2.16
$\frac{K_2O'}{Na_2O'}$	0.28	0.38	0.40	0.59	0.26

By the quantitative system, A, D, E, and F would be classified under the name andose and G under akerose.

From the tables given above, it is clear that the rocks from Fukae differ from normal basalt, in containing a high percentage of alkalies in proportion to the silica contents, especially of soda, forming normative andesine $Ab_{58}An_{42}$, which is slightly more calcic than the modal plagioclase. Though the alkali-feldspar is not present as a recognizable mineral in the first type (Bomb) of the first rock group, its molecule is to be looked for in the glass-base. In the second and third type, the alakli-feldspar is seen in the modal state. The chemical resemblance between the rock of Fukae, A, and the olivine-basalt from St. George's Head, E, is very close. The differences between them are lower potash for orthoclase, slightly higher soda for plagioclase and higher normative ilmenite in the Fukae rocks, compared with the olivine-basalt, of St. George's Head. Generally the rock is characterized by properties mineralogically and chemically intermediate between the mugearite, G, described by Harker, and the olivine-basalt described by Card, though it is very near to the last rock, and it differs from shoshonite described by Iddings in being dosodic.

The rock from Madara-shima, D, differs slightly from the Fukae rock in the lower value of magnesia and in higher percentages of silica and potash, and of alumina which increases the normative anorthite. It has a close resemblance in chemical characters to the orthoclase-bearing doleritic basalt, F, from Croobyar Creek, New South Wales, described by Card.